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Technological capabilities and the decision to outsource/outsource offshore R&D services

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ABSTRACT

We analyze firm and environmental factors influencing the decision to outsource and outsource offshore R&D services. To do so, we have adopted a co-evolutionary approach adapted to firm internationalization, according to which these decisions are conditioned by the institutional environment (the IPR system), managerial intentionality (firms' international strategy) and organizational path dependence and learning (firms' technological and governance capabilities). Specifically, we argue that: (1) firms with more technological capabilities will tend to both outsource and outsource offshore R&D services, (2) the positive effect of technological capabilities would be leveraged when the institutional context of the firms' country of origin has allowed them to transform their technological expertise into governance capabilities, and (3) that those firms with a higher local responsiveness attitude will be more likely to outsource offshore R&D services. We have found support for our hypotheses using survey data from a sample of 182 technology intensive firms from the European Union and the US.

1. Introduction

Transaction cost economics posits that the characteristics of each transaction determine whether such transaction is going to be organized internally or outsourced (Coase, 1937; Williamson, 1975, 1985). For this reason, the study of outsourcing decisions has been traditionally conducted at the transaction level (Hill, 1990; Masten, Meehan, & Snyder, 1991; Monteverde, 1995; Williamson, 1975, 1985). However, the focus has shifted to also highlight the role of firms' capabilities (Parmigiani, 2007; Rothaermel, Hitt, & Jobe, 2006; Williamson, 1999) together with the role of firms' strategy and firms' environment (Lewin, Massini, & Peeters, 2009). Conventional wisdom hitherto assumed that, when it came to outsource activities related to a firm's competitive advantage, these activities tended to be integrated within the firm in order to fully exploit these capabilities and protect them from expropriation by potential partners (Agyres, 1996; Leiblein & Miller, 2003; Nickerson & Silverman, 2003). However, the recent work of Mayer and Salomon (2006) has shown that the possession of valuable technological capabilities can also lead to outsource technological areas, as firms having such valuable technological capabilities are better prepared to identify, negotiate and monitor external providers of technology and technological services. In addition, several streams of research have been highlighting the role of the institutional environment in explaining decisions related to the organization of R&D activities (Belderbos, Fukao, & Ug Kwon, 2006; Hagedoorn, Cloodt, & van Kranenburg, 2005; Lewin et al., 2009; Oxley, 1999).

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One of the areas in which the importance of outsourcing has risen in recent years is the field of R&D, where offshore outsourcing has risen during the last decade (Lewin et al., 2009; Manning, Massini, & Lewin, 2008). Due to the growing complexity and multidisciplinary nature of the innovation process, and thanks to IT advances that allows for the codification and modularization of knowledge, the same offshore outsourcing phenomenon that took place decades ago with firms' production activities is now re-occurring in relation to the different stages in the firms' R&D value chain (Fosfuri & Roca, 2002; Pavitt, 1999). Firms are increasingly outsourcing, either via arms' length contracts or strategic alliances, some of the R&D services integrating their innovation process to externalized providers located worldwide, not only to reduce costs but also to access external technological knowledge (Bunyaratavej, Hahn, & Doh, 2007; Kotabe & Murray, 2004; Lewin & Peeters, 2006). Thus, the dividing line between those R&D services that are better kept at home and those that are better outsourced has become blurred (UNCTAD, 2005). However, despite this growing propensity to outsource R&D services, our own survey findings show that some firms still maintain all of their R&D services in-house, while previous research data shows no conceptual agreement on the relation between R&D intensity and outsourcing (Mol, 2005).

Taking all of this into account, in this paper we analyze how firms' technological capabilities, together with their international strategy and institutional context, influence both the decision to outsource in the general sense, and more specifically to outsource offshore R&D services. While interesting literature dealing with firm R&D boundaries decisions does exist (Arora, Arunachalam, Asundi, & Fernandes, 2000; Fosfuri, 2006; Narula & Dunning, 1998; Nicholls-Nixon & Woo, 2003; Pisano, 1990; Rothaermel et al., 2006; Ulset, 1996), to the best of our knowledge, no studies have yet addressed the relationship between a firm's technological capabilities, its international strategy, its institutional environment, and its propensity to outsource R&D services either domestically or offshore. In keeping with a co-evolutionary view of firms' capabilities and governance choices (Hutzschenreuter, Pedersen, & Volberda, 2007; Lewin & Volberda, 1999; Volberda & Lewin, 2003), we argue that firms' contractual preferences will change as they accumulate technological capabilities, although these changes would also be dependent on the institutional environment (the intellectual property rights system) and managerial intentionality (firms' international strategy). More specifically, we argue that: (1) firms with more technological capabilities will tend to outsource R&D services both at the home country and offshore, (2) the positive effect of technological capabilities would be leveraged when the institutional context of the firms' country of origin has allowed them to transform their technological expertise into governance capabilities, and (3) that ceteris paribus those firms with a higher local responsiveness attitude will be more likely to outsource offshore R&D services. Therefore, from a theoretical perspective, our paper is an extension of the literature analyzing technological capabilities and governance to the field of R&D services. More specifically, we show that the IPR of the firms' home country appears to be the missing link between technological capabilities and the firms' capability to govern R&D outsourcing agreements. From a practical perspective, our study contributes further proof that not all firms are equally prepared to benefit from either outsourcing or offshore outsourcing practices related to the R&D function.

Empirically, we test our hypotheses using original international firm-level survey data on R&D services outsourcing conducted on a sample of firms competing in R&D intensive industries (Chemical, Electric, Machinery, Transportation, and Precision Instruments). The data was collected during the period between July 2006 and February 2007. Our final sample includes 182 firms, of which 74 claimed to not to outsource any R&D service (40% of our sample) and 108 claimed to outsource at least one R&D service (60% of our sample).

2. Theoretical background and hypotheses

When facing the decision to outsource R&D, firms analyze the trade-off that exists between, on the one hand, the benefits stemming from taking advantage of external knowledge and capabilities and/or from low labor costs and, on the other hand, the risks associated with opportunism on the side of the external contractor. Although the attributes of each transaction influence both the costs and benefits of outsourcing, these costs and benefits are also affected by two firm characteristics as well as by the environment. The first firm characteristic affecting the outsourcing decision is the degree of accumulation of technological capabilities, which become an advantage in selecting and managing the relationship with an external supplier, in aspects like arranging contracts, transferring the required know-how and evaluating and monitoring the performance of this supplier, reducing thus transaction costs (Mayer & Salomon, 2006). More specifically, we argue that firms having valuable technological capabilities would not have incentives to perform all of the activities of their R&D process in house, especially in high-tech industries. In these industries, competitive pressures to build a larger and broader portfolio of related products in order to gain and maintain a competitive advantage has led firms to rely in external suppliers to organize some R&D services (Leiblein & Miller, 2003; Mol, 2005; Nicholls-Nixon & Woo, 2003; Quinn, 2000). By doing so, they can concentrate on those parts of the process in which they can exploit their competitive advantage. These firms will also be better equipped to avoid contracting hazards, as technological capabilities allow them to select capable suppliers and to better monitor their behaviour (Mayer & Salomon, 2006). The second firm characteristic affecting the outsourcing decision is the firm's international strategy, given that whenever a strategy of local responsiveness is adopted, the need of external resources will increase the propensity to outsource. As firms following these strategies need to adapt their products to multiple markets (Bartlett & Ghoshal, 1989), they will have a higher propensity to outsource. While the influence of firms' international strategy on the decision to outsource is somewhat straightforward, the influence of the technological capabilities is leveraged by the institutional environment surrounding each firm. Even though firms with technological skills are better prepared to govern technology alliances (Mayer & Salomon, 2006), the development of governance capabilities

require the accumulation of experience in alliances and technology transfer, but this propensity to form alliances will be dependent on the institutional environment, and specifically on the degree of protection of intellectual property rights (IPR). We argue that this propensity to rely on external suppliers will be reduced in those contexts where the firm has not accumulated experience in the management of technology alliances or R&D outsourcing due to a weak protection of intellectual property rights in its country of origin. On this basis, we argue that the decision to outsource is not only dependent on firms' resources and learning experience, but also on the institutional environment. Due to the joint influence of environment forces, firm strategy and experiential learning, we adopt a co-evolutionary approach (Lewin & Volberda, 1999; Volberda & Lewin, 2003) adapted to firm's internationalization, following Hutzschenreuter et al. (2007). In this way, we argue that both the outsourcing and the offshore outsourcing decision are conditioned by the institutional environment (firms' home country intellectual property rights system), managerial intentionality (firms' international strategy) and organizational path dependence and learning (firms' technological and governance capabilities). Our framework is developed in the following paragraphs.

2.1. Technological capabilities

When it comes to outsourcing R&D services, firms with sound technological capabilities are bound to have an edge over the competition. Initially, it could be expected that the more technological resources and capabilities a firm has, the less it will need to search for external sources of innovation. However, these capabilities can be leveraged if some specific parts of the R&D process are outsourced to an external firm, that is combining vertical integration and strategic outsourcing—organizational practice known as "taper integration" (Rothaermel et al., 2006). It bears mentioning that the innovation process, like many other business functions (Gottfredson, Puryear, & Phillips, 2005), is integrated by different and technologically separable stages or services that can be classified in a continuum from very strategic or "core" to the firm to those being less strategic or "non-core" to the firm. For this reason, many firms are partially integrated and simultaneously outsource some activities in the R&D process (Afuah, 2001). Some firms even follow a concurrent sourcing strategy, i.e. they simultaneously make and buy the same good or service (Parmigiani, 2007). As a result of this, we expect that firms competing in technology intensive industries will need to search for efficient ways of relocating and organizing their different R&D services worldwide (Mudambi, 2008; Swamidass & Kotabe, 1993). This would imply that, when possible and available, these firms will prefer to outsource their R&D services to best-in-world providers in order to maintain its competitive advantage. Furthermore, the more technological capabilities the firm has, the more we expect that the likelihood of outsourcing R&D services will be increased. Firms having valuable technological advantages can leverage their own resources if they concentrate their R&D efforts if they only perform in-house those activities directly related to their competitive advantage, relying the remaining activities on external suppliers. If we take into account that firms usually do not accomplish the same efficiency levels across all the stages within the R&D process (Fosfuri & Roca, 2002; Pavitt, 1999) and that the external providers have complementary capabilities and can benefit from economies of scale and scope unavailable for the firm, the benefits from such concentration are justified. It is evident that firms lacking valuable technological resources could also benefit from external sources of R&D services. However, they may not have the ability to select, negotiate and monitor the behaviour of their external suppliers (Mayer & Salomon, 2006) or to effectively transfer the required know-how. Due to the fact that firms have different abilities to absorb and transfer foreign knowledge, this will help determine which firms are able to use foreign R&D as part of a strategy to augment their technological capabilities (Berry, 2006). Consequently, when considering the R&D outsourcing decision, the accrued technological capabilities are expected to be critical in order to identify criteria to select and monitor the best provider, as well as to reach an acceptable agreement regarding the price and other terms of the contract. Thus, firms lacking valuable technological resources and capabilities are expected to face higher information asymmetry problems, due to their difficulties in correctly assessing their potential providers and, as a result, they may be subject to higher hazards of opportunistic behaviour. On the contrary, those firms in possession of greater technological capabilities can take advantage of them to better select, negotiate and monitor the best external suppliers (Mayer & Salomon, 2006). As a result, the lower the value of the technological capabilities possessed by a firm, the higher the information asymmetry that may exist between this firm and an external supplier. This information asymmetry may lead to ex-ante and ex-post transaction costs (Akerlof, 1970; Hoetker, 2005; Klein, Crawford, & Alchian, 1978). Thus, those firms lacking valuable technological resources will be less well-equipped to select an appropriate partner, which will cause them to face some adverse selection problems, and be ill-equipped to monitor their performance. It is important to note that, whereas firms with underdeveloped technological capabilities may face information asymmetry problems when outsourcing in their home country, this asymmetry would be higher in the case of offshore outsourcing agreements, which imply operating in a different context in such a way that it is more difficult to identify relevant partners and monitor their performance (Barkema, Shenkar, Vermeulen, & Bell, 1997; Hitt, Dacin, Levitas, Arregle, & Borza, 2000). Note that it could be the case that those firms lacking technological capabilities may decide to leave selection and monitoring of R&D providers to an external firm—that is, outsource it. However, as in this paper we are explaining the propensity of firms to outsource or outsource offshore R&D services, we expect that if firms face problems finding and monitoring suppliers—because they lack technological capabilities—these firms will face the same contractual problems in order to find and monitor the required intermediaries. Therefore, our argument is that, although firms may use these intermediaries in some cases, their propensity to outsource R&D services overall will be lower compared to that of firms equipped with greater technological capabilities. Thus, these arguments lead to the following hypotheses:

Hypothesis 1a. As firm's technological resources and capabilities increase, its propensity to outsource R&D services also increases.

Hypothesis 1b. As firm's technological resources and capabilities increase, its propensity to outsource offshore R&D services also increases.

2.2. The role of intellectual property rights (IPR)

As shown in previous studies (Gatignon & Anderson, 1988; Henisz, 2000; Henisz & Williamson, 1999) the contractual hazards originated from a transaction—hold-up hazards, risks of technological leakage or expropriation hazards—are not independent from the institutional environment that surrounds the transaction. In this regard, it is important to distinguish between two types of transaction costs: contractual and appropriability hazards. Although governance capabilities stemming from technological resources may reduce contractual hazards, they cannot easily reduce appropriability hazards (Mayer & Salomon, 2006). The protection of firm-specific knowledge is highly dependent on the effectiveness of the level of protection of intellectual property rights system, which varies across countries. In high-technology industries, and due to the specific nature of the technological knowledge, the protection of intellectual property rights is expected to be crucial, as non-protection of the firm's technological knowledge may imply high risks of imitation from competitors, which may lead to an erosion of the firm's competitive advantage. Thus, there may be situations where firms with greater technological resources may decide not to outsource R&D services due to the lack of protection of intellectual property rights. In these cases the risk of technological leakage or expropriation would prevent the firm from using an external provider (Teece, 1986).

In relation to this, and in keeping with a co-evolutionary approach, it is important to notice that technological resources may not be transformed automatically into governance capabilities for outsourcing agreements. Even though there is no empirical research on this matter conducted in the field of outsourcing agreements, this assertion can be supported by taking into account the literature on strategic alliances. Previous research on the development of alliance management-related capabilities suggest that they are developed over time as firms accumulate experience in the different type of alliances (Ethiraj, Kale, Krishnan, & Singh, 2005; Westney, 1988) and also depending on the adoption of several routines and internal organizational arrangements to transform this experience into alliance capability (Draulans, de Man, & Volberda, 2003; Kale, Dyer, & Singh, 2002; Simonin, 1997). For this reason, the impact of firms' technological resources and capabilities in the governance of outsourcing agreements would increase as firms gain experience in outsourcing. In addition it has also been documented that the most relevant alliance capabilities are developed in the firm's country of origin. Barkema et al. (1997) found that, whereas company's prior experience in domestic JVs lengthened the life of international JVs, previous international experience did not. They concluded that domestic alliances were a stepping stone in the process of successfully launching international alliances, as firms learn to handle these agreements without the additional complexities of international operations. Thus, taking advantage of technological resources and capabilities in order to govern offshore R&D outsourcing agreements require the accumulation of relevant experience in domestic agreements. For this reason, firms with a weak protection of intellectual property rights at their domestic market would not be able to easily develop enough governance capabilities at home, as they would be reluctant to outsource R&D services. This preference for vertical integration would be reinforced taking into account that it would pose a difficulty in the development of a local market of R&D services providers, which at the end further reduces the probability of domestic outsourcing. On the other hand, the higher the protection granted by the IPR system, the higher the accumulation of governance capabilities at home due to the lower transaction costs the firm will have to incur in order to protect itself from the risk of opportunism by a third party. Consequently, these firms with domestic R&D outsourcing experience would be better prepared to manage R&D agreements offshore. Note that intellectual property rights protection in a foreign country is less relevant when it comes to explaining offshoring decisions, as firms can choose a location with strong intellectual property rights protection when necessary. As a result, it can be hypothesized that:

Hypothesis 2a. The higher the level of protection of intellectual property rights in the firms' country of origin, the higher the propensity to outsource R&D services of those firms having greater technological resources and capabilities.

Hypothesis 2b. The higher the level of protection of intellectual property rights in the firms' country of origin, the higher the propensity to outsource offshore R&D services of those firms having greater technological resources and capabilities.

2.3. The need to achieve local responsiveness within the firm's international corporate strategy

Similarly to FDI literature on R&D, previous research shows that overall firms may decide to outsource some of their R&D services to a third party, either to exploit their technological knowledge (efficiency reasons) or to explore or acquire new one (knowledge reasons) (Hagedoorn, 1993; Kuemmerle, 1999; Mol, 2005). In relation to the R&D function, the dispersion of technological knowledge implies a greater need for technology managers to engage in finding new sources of knowledge. Because R&D services are knowledge-based activities, and knowledge tends to be location-specific, some regions may offer specialized know-how or capabilities within a specific technological domain. With regard to this, research has shown that the dispersion of R&D activities is largely a result of the emergence of increasingly specialized-niche business activities,

many of which are strongly tied to a particular geographic space (Calderini & Scellato, 2005; Cantwell & Santangelo, 1999). For instance, Cantwell and Santangelo (1999) found firms' R&D spending to be highly localized in the parent company; however, they found that there are some situations in which firms decide to outsource offshore R&D mainly for two reasons: (1) either because certain knowledge is only available in one or a few foreign clusters, or (2) because of the ability of multinational firms to develop a global knowledge exploration network inside and around the firm. Consequently, it can be expected that when firm managers choose to follow a local responsiveness strategy (Bartlett & Ghoshal, 1989), they may need to be more open to external sources of technological knowledge. For example, new product development in a transnational context (i.e. those cases in which local adaptations are critical to the success of the innovation) requires the joint use of knowledge dispersed in multiple countries (Mudambi, 2002; Subramian & Venkatraman, 2001). Thus, for those firms willing to adapt their new products to multiple local environments, R&D outsourcing agreements with offshore providers located in the different local markets the firm is operating may serve as a mechanism to gain access to the local knowledge necessary to adapt their products or processes to the local requirements. Furthermore, R&D offshore outsourcing agreements with providers in the local markets may serve as a mechanism to identify the potential for new products and services or faster and better access to new technologies. Therein, it can be expected that those firms willing to be locally responsive (Bartlett & Ghoshal, 1989) would have more incentives to outsource offshore as they need to access local knowledge in order to adapt their products or processes to those local markets. Consequently, it can be hypothesized that:

Hypothesis 3. Firms following an international strategy based in achieving local responsiveness will have a higher propensity to outsource offshore R&D services than the rest of the firms.

3. Methods

3.1. Data and sample

The data used in this paper stems from an international survey on R&D service outsourcing, conducted on a sample of firms competing in R&D intensive industries. We sent a questionnaire to firms headquartered either in the US or in the European Union (EU) with more than 100 employees and whose first 2-digit SIC code was one of the five defined in the OECD classification of sectoral R&D intensities as technology intensive industries (OECD, 1997): chemicals and pharmaceuticals (SIC 28), transportation equipment (SIC 35), computers and electronics (SIC 36), industrial machinery (SIC 37), and analysis and measurement equipment (SIC 38). This is an interesting setting to study this phenomenon if we consider that efficient R&D management plays a crucial role in the competitive strategy of these industries. We stratified the sample according to country, industry and firm size to ensure external validity, using both domestic and international versions of the *Dun & Bradstreet Million Dollar Database*, which spans all industries providing information on companies with $1 million or more in sales, or 20 or more employees. Using these criteria, we obtained a list of 3529 U.S. firms and 3375 EU firms. From these lists, we randomly selected stratified samples of 2000 firms from the U.S. and 2000 from the EU. In order to better understand the R&D outsourcing phenomenon and to develop a more comprehensive questionnaire, we conducted interviews with the heads of Technology and Innovation of a large US-based multinational company. Furthermore, the questionnaire was pre-tested on seven R&D managers located in different countries. Due to the international nature of the targeted population the questionnaire was translated into five languages: English, French, Italian, Spanish, and German. Given the varying sizes of the firms and industries included in our targeted population, the questionnaire was mailed to the firms' CEOs along with a request to pass it on to the head of R&D or technology if necessary. We also made all versions of the questionnaire available on the Internet. The returned questionnaires were filled out by senior managers, namely, CEOs, VPs, heads of R&D or heads of technology or engineering departments.

We followed the principles of the Total Design Method (Dillman, 1978). A total of 105 completed questionnaires were received from the first mailing in July 2006. A second mailing was sent three months later and an additional 33 questionnaires were received. 303 mailings were returned as undeliverable (197 for the U.S. and 106 for the EU). After a telephone follow-up process, 44 extra questionnaire replies were collected. Thus, we obtained a final sample of 182 usable responses (81 for the U.S. and 101 for the EU). After excluding the undeliverable addresses, our response rates were 4.5% for the U.S. and 5.3% for the EU. It must be noted that cross-national mail surveys aiming at an industrial population generate very low response rates, normally similar to those obtained in this study (see for instance, Yip & Dempster, 2005). In addition to this, there are virtually no alternatives to mail surveys in an international context if more than a couple of countries are included (Harzing, 2000a). We also called some of our non-respondents and asked them to indicate the reason for not wanting to participate. According to them, managers are subject to such a competitive pressure and short deadlines that they do not find the time to answer questionnaires. Besides, firms, and more particularly top managers, are receiving so many questionnaires per month that most of the companies have decided to establish a policy to not allow employees to answer any. Thus, firms are subject to "questionnaire fatigue" (Harzing, 2000a). Furthermore, the complexity of the topic object of our study negatively influences response rates. However, despite this, the 182 responses obtained are representative of the spectrum of firms in terms of industry, country of origin, and firm size (see Table A1 in Appendix A for the distribution by firm, country of origin, and industry). We also compared the responses from first mailing and those from the second but we found no significant differences at the 95% confidence level between early and late respondents in terms of firm size or the decision to outsource R&D. We can thus conclude that a significant non-respondent bias is unlikely.

Table 1
Number of R&D services being outsourced by firm and by industry[a].

# R&D services outsourced	Industries					# Total firms
	Chemicals and pharmaceuticals	Machinery	Electronic equipment	Transportation	Precision instruments	
1	4	9	5	2	2	22
2	5	5	6	1	1	18
3	7	1	4	2	1	15
4	1	0	1	3	3	8
5	3	5	2	0	4	14
6	1	2	0	1	1	5
7	1	2	0	0	3	6
8	2	0	0	0	0	2
9	1	1	1	1	0	4
10	0	0	0	0	1	1
11	0	2	0	0	0	2
12	2	3	5	1	0	11
# Total firms	27	30	24	11	16	108
% outsourcing firms ($N = 108$)	25%	27.78%	22.22%	10.19%	14.81%	100%
% total sample ($N = 182$)	14.84%	16.48%	13.19%	6.04%	8.79%	59.34%

[a] The R&D services included are: basic or fundamental research, applied or experimental research, development of new products or new or improved processes, product design, design of technology processes and engineering systems, architectural services, software development, scientific and technical support, consulting services, software implementation services, and testing and analysis services.

We asked firms to indicate which R&D services they were outsourcing from a comprehensive list of twelve, and where. For this purpose, after making an exhaustive literature review of academic papers, reports and firms' websites, we managed to create a service list of different R&D services or stages that we found were usually integrating firms' innovation processes. This was revised by a consulting firm and several R&D managers who helped us to better define the list. After their reviews, our final list comprehends 12 different R&D services. Given this list, 108 of the 182 firms outsource at least one of the R&D services listed (60% of our sample). The distribution of number of services being outsourced by firm and by sector of activity is the following (see Table 1).[2] For more details on the survey data collected see Martínez-Noya and García-Canal (2010).

3.2. Dependent variable and method of analysis

In order to test our hypotheses, we use a probit model. The make vs. buy literature has often employed binary choice models in order to analyze the relationship between a set of covariates and the make vs. buy decision (Mayer & Salomon, 2006; Pisano, 1990; Poppo & Zenger, 1998). Given this dichotomous variable, a logit or probit model is the preferred estimation technique (Kennedy, 1998). In this case, we use the probit model as its maximum-likelihood estimation procedure is particularly appropriate for dealing with the qualitative data employed in this study. For the purpose of this paper two different probit models are presented: one probit model to explain the R&D outsourcing decision, and another probit model to explain the R&D offshore outsourcing decision.

On the one hand, the dependent variable in the first probit model (OUTSOURCING) is a binary one and determines whether or not the firm outsources any of the twelve R&D services listed in the questionnaire, either to providers located at the home country or abroad. Thus, the dependent variable equals 1 if the firm does outsource one or more of the R&D services and 0 if the firm does not outsource any of them. On the other hand, in the second probit model presented, the dependent variable (OFFSHORE OUTSOURCING) is binary and determines whether or not the firm outsources offshore, any of the R&D services. As a result, this variable takes value 1 if the firm does outsource offshore one or more of the R&D services, while equals 0 if the firm does not outsource offshore any of them.

In the probit model, a positive sign of the coefficient indicates that the effect of the variable on probability of outsourcing (or offshore outsourcing) is positive, while a negative sign indicates that the effect on probability of outsourcing (or offshore outsourcing) is negative.

3.3. Independent variables

The independent variables used in both probit models were constructed as follows:

PATENTS. As an indicator of the firm's technological resources we use the number of patents that have been assigned to the firm until 12/31/2006. Because experience and capabilities are developed and accumulated over time, we accounted for the complete track record of patents assigned to the firm. Patent data have also been used by previous studies to measure technological capabilities of the firm in high-technology industries (Bachmann, 1998; Praest, 1998; Tallman &

[2] See Fig. A1 in Appendix A for an illustration of the offshore destinations were the firms in our sample indicated to be outsourcing R&D services.

Phene, 2007). To build this variable, we gathered the data recorded in the United States Patent Trademark Office (UPSTO). This information was obtained from the web page http://www.upsto.gov.

IPR. This variable is obtained from the index of protection of intellectual property rights (IPR) developed by Ginarte and Park (1997) and updated by Park for the year 2000. This index has been widely used in the literature (Belderbos et al., 2006; Nicholson, 2007; Oxley, 1999) and it assigns a value from 0 to 5 to each country depending on its national patent legal system (value 5 indicating maximum protection). The relative superiority of this index compared to other alternative measures is due to the fact that this index describes in more detail the standards of the intellectual property rights, which leads to a greater variability of the index, both among countries and time. In order to test our hypotheses, we took the value of the index for the firm's home country. This is an indicator of the strength of the intellectual property rights system at the firm's home country.

LOCAL RESPONSIVENESS. To capture the firm's willingness to be locally responsive, we developed this dummy variable that takes a value 1 if the firm is a multinational firm with a multi-domestic or transnational international corporate strategy and 0 otherwise. This variable was developed using the technique and the four questionnaire items developed by Harzing (2000b) to empirically test Bartlett and Ghoshal's (1989) typology of multinational firms. These items measure the importance in the firm's corporate strategy of competing on a global or a local basis on the one hand, and achieving economies of scale or local responsiveness on the other.[3]

OTHER MNEs. Dummy variable that takes a value 1 if the firm is a multinational following a corporate strategy not classified as multi-domestic or transnational, and 0 otherwise. Domestic firms act as a reference for these two last variables.

3.4. Control variables

In order to account for firm heterogeneity, we introduced other additional control variables that may also affect the propensity to outsource or to outsource offshore R&D services. More specifically, we have included the following control variables in both models:

R&D CENTRALIZATION: We classified firms' R&D organization into four archetypes according to the typology developed by Von Zedwitz and Gassmann (2002), which classifies firms into four archetypes—national treasure, market-driven, technology-driven, and global—according to their motivation to either access local markets and clients, or their motivation to access local science and technology. Different strategies require different decisions; thus, given that the level of internationalization of the firm R&D activities may influence its ability to access new sources of technological knowledge or its ability to achieve economies of scale, this variable controls for firm international configuration of R&D activities. Consequently, we control for those firms that indicated that they do concentrate their R&D activities at their home country—i.e., those following the national treasure typology—, vs. other configurations, using a dummy variable that takes a value 1 if the firm concentrates its R&D activities in its home country and 0 otherwise.[4]

R&D BUDGET: We introduced this variable to control for firm R&D budget. This control variable is operationalized as the logarithm of the firm's 2005 R&D expenditures (in dollars). This variable can be also considered as a control for firm size, as it was highly correlated not only with firm sales during 2005 (correlation = 0.91) but also with the firm number of employees (correlation = 0.89). We also ran models using firm sales and the number of employees as alternative measures of firm size, which yielded the same results.

FIRM INDUSTRY: We introduced dummies to control for the industry the firm operates—SIC 28 (Chemicals); SIC 36 (Electronics); SIC 37 (Machinery); and SIC 38 (Measurement Equipment). In order to run the models SIC 35 (Transportation Equipment) was omitted and used as the reference category.

Table 2 presents the descriptive statistics and the correlations between independent and control variables. In general, there are no high correlations. Except from the correlation between the dummy variables LOCAL RESPONSIVENESS and OTHER EMNs ($r = -0.56$), most correlations are low. Given the high correlation between the interaction terms and the main effects, we mean-centered the continuous variables PATENTS and IPR before calculating the interactions (Jaccard & Turrisi, 2003) in both models.

[3] Following Harzing's (2000b) work, we asked firms to indicate their level of agreement on a Likert scale from 1 (low) to 5 (high) with the following statements: (1) our company's strategy is focused on achieving economies of scale by concentrating its most important activities at a limited number of locations; (2) competition in our sector takes places on a global basis; (3) our company's competitive strategy is to let each subsidiary compete on a domestic level as national product markets are judged too different to make competition on a global level possible; (4) our company tries to respond to national differences by adapting products and strategies to the local market.

[4] In order to develop this variable we asked firms to indicate which of the following statements best described their company's international configuration of R&D activities. The options were: (1) our company concentrates all of its research and development activities at home; (2) our company concentrates its basic research activities at home but internationalizes its development activities to adapt its products and/or processes to foreign markets; (3) our company centralizes its development activities at home but internationalizes its research activities to centers of excellence abroad; or (4) our company has its research and development activities located worldwide.

Table 2
Descriptive statistics and correlation matrix.

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. OUTSOURCE	0.59	0.49													
2. OFFSHORE OUTSOURCING	0.37	0.48	0.64*												
3. PATENTS (mean centered)	0	236.73	0.13	0.22*											
4. IPR (mean centered)	0	0.39	0.09	0.04	0.15*										
5. PATENTS × IPR	14.22	1170.65	0.15	0.22*	0.83*	−0.04									
6. LOCAL RESPONSIVENESS	0.48	0.50	0.15*	0.26*	0.08	0.05	−0.00								
7. OTHER MNEs	0.43	0.49	−0.14*	−0.21*	−0.04	−0.02	0.01	−0.56							
8. R&D CENTRALIZATION	0.49	0.50	−0.16*	−0.36*	−0.20*	−0.07	0.25	−0.27*	0.29*						
9. R&D BUDGET (log)	19.28	1.78	0.10	0.28*	0.44*	0.13	−0.15*	0.28*	−0.26*	−0.37*					
10. SIC 28	0.24	0.43	0.00	0.05	0.08	−0.16*	0.11	0.03	0.03	−0.08	0.08				
11. SIC 35	0.31	0.46	−0.10	−0.04	−0.03	−0.01	0.02	−0.16*	0.05	−0.03	−0.23*	−0.39*			
12. SIC 36	0.21	0.41	0.00	−0.08	−0.02	0.08	−0.00	0.12	−0.09	0.11	−0.02	−0.30*	−0.36*		
13. SIC 37	0.08	0.28	0.05	0.07	−0.06	0.07	−0.06	0.04	−0.00	0.08	0.17*	−0.17*	−0.21*	−0.16*	
14. SIC 38	0.12	0.33	0.07	0.04	0.01	0.06	−0.10	−0.00	−0.00	−0.04	0.11	−0.21*	−0.26*	−0.20*	−0.11

* Significant at the 5% level.

Table 3
Estimates of probit models proposed.

Independent variables	OUTSOURCING			OFFSHORE OUTSOURCING		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
PATENTS		0.001	0.001		0.001	0.001
		(2.04)**	(0.36)		(1.94)**	(0.19)
IPR		0.186	0.484		−0.051	0.182
		(0.72)	(1.78)*		(0.20)	(0.70)
PATENTS × IPR			0.007			0.006
			(2.69)***			(2.86)***
LOCAL RESPONSIVENESS		0.162	0.186		0.732	0.765
		(0.42)	(0.48)		(1.78)*	(1.87)*
OTHER MNEs		−0.150	−0.154		0.296	0.294
		(0.39)	(0.40)		(0.71)	(0.71)
R&D CENTRALIZATION	−0.465	−0.385	−0.347	−0.845	−0.774	−0.732
	(2.21)**	(1.78)*	(1.59)	(3.82)***	(3.40)***	(3.20)***
R&D BUDGET (log)	−0.001	−0.075	−0.057	0.116	0.046	0.071
	(0.02)	(1.11)	(0.79)	(1.88)*	(0.65)	(0.97)
SIC 28 (Chemicals)	0.199	0.237	0.245	0.066	−0.006	−0.011
	(0.78)	(0.89)	(0.90)	(0.25)	(0.02)	(0.04)
SIC 36 (Electronics)	0.277	0.235	0.225	−0.108	−0.238	−0.275
	(1.03)	(0.86)	(0.81)	(0.37)	(0.80)	(0.89)
SIC 37 (Machinery)	0.537	0.609	0.609	0.409	0.403	0.386
	(1.39)	(1.48)	(1.47)	(1.06)	(1.00)	(0.94)
SIC 38 (Measurement Equipment)	0.411	0.427	0.533	0.109	0.064	0.150
	(1.24)	(1.25)	(1.50)	(0.31)	(0.18)	(0.40)
Constant	0.285	1.668	1.243	−2.206	−1.324	−1.895
	(0.24)	(1.23)	(0.86)	(1.81)*	(0.93)	(1.28)
Log pseudo-likelihood	−118.182	−115.431	−112.775	−104.724	−100.649	−98.165
Percentage of cases correctly classified	63.54%	66.85%	66.85%	70.17%	70.72%	70.72%

Robust *z* statistics in parentheses.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

4. Results

Table 3 reports the results from the probit models explaining, on the one hand, the R&D outsourcing decision and, on the other hand, the R&D decision to outsource offshore. For each probit model, three different specifications are presented: control variables only (models 1 and 4), control and independent variables (models 2 and 5), and control and independent variables with interaction effects for technological resources with the level of protection of IPR (models 3 and 6). Specifically, the table shows the value of the regression coefficients, their standard error and an indication of their significance level for each model. As expected, an *F*-test of the null hypothesis that all the coefficients are jointly zero is rejected in all models. The results are consistent across specifications.

Table 4
Effect of IPR on the marginal effect of PATENTS on the probability of R&D outsourcing and R&D offshore outsourcing.

Value of moderator IPR	Marginal effect of PATENTS[a]	*z*-Statistic
Outsourcing		
Low	−0.0047*	−1.78
Mean	0.0000846	0.36
High	0.00053*	1.68
Offshore outsourcing		
Low	−0.00025*	−1.77
Mean	0.0000238	0.19
High	0.000333*	1.85

[a] Computed at sample mean value of PATENTS.
* $p < 0.10$.

As can be seen in Table 3, the results of the estimations confirm our hypotheses. It can be observed that, in accordance with Hypothesis 1a and Hypothesis 1b, the PATENTS variable presents a positive sign and is statistically significant in models 2 and 5. This confirms that the likelihood of either outsourcing or offshore outsourcing an R&D service increases the more technological resources the firm has.

According to Hypotheses 2a and 2b, it can be observed that the coefficient of the interaction PATENTS × IPR is highly significant in both probit models. However, the interaction effect cannot be evaluated simply by looking at the sign, magnitude, or statistical significance of the coefficient on the interaction term when the model is nonlinear, such as the probit model (Ai & Norton, 2003; Wiersema & Bowen, 2009). Instead, the interaction effect must be tested by examining the sign and statistical significance of the values of the moderator variable's marginal effect (i.e. IPR) on the relationship between the explanatory variable (i.e. PATENTS) and the dependent variable over all sample values of the model variables. So, once we followed the guidelines given to analyze this true interaction effect by the works of Ai and Norton (2003) and Wiersema and Bowen (2009) we obtained that in both probit models the true interaction effect is positive and significant (*z*-statistic value of 2.64 for the OUTSOURCING model and a value of 2.88 for the OFFSHORE OUTSOURCING model, with $p < 0.001$) for virtually all the observations in our sample, except for those with a predicted value of outsourcing or offshore outsourcing R&D services higher than 0.98.[5] Table 4 shows the effect of IPR on the marginal effect of PATENTS on the probability of OUTSOURCING and OFFSHORE OUTSOURCING, respectively. As shown in this table, the relationship between PATENTS and both the probability of OUTSOURCING or OFFSHORE OUTSOURCING is clearly positive and significant at higher values of IPR, while it is negative and significant for lower values of IPR. Thus, these results confirm our argument that firms' technological capabilities are not automatically transformed into governance capabilities, as firms having a weak protection of intellectual property rights at their domestic market may not be able to easily develop enough governance capabilities at home, and as a consequence they would be more reluctant to outsource R&D services both domestically and offshore. These results confirm Hypotheses 2a and 2b.

Finally, Hypothesis 3, relating to the probability of offshore outsourcing R&D services, is also confirmed. Our dummy variable LOCAL RESPONSIVENESS presents a marginally significant and positive sign in models 5 and 6. Note that, because we introduced two of the three dummy variables associated with corporate strategy (the dummy variable valued one for domestic firms are omitted), estimated coefficients for these variables measure the degree to which the impact of this variable on the probability to outsource offshore R&D services is significantly different (higher or lower) than that the omitted variable (Kennedy, 1998). This indicates that multinational firms pursuing an international corporate strategy where being locally responsive is very important are more likely to outsource offshore R&D services compared to domestic firms. As expected, although still positive, LOCAL RESPONSIVENESS is non-significant in order to explain the probability to outsource R&D services.

Regarding the control variables introduced, none of them seem to be statistically significant across models expect from R&D CENTRALIZATION, that has a negative and significant coefficient across models, especially when explaining the probability of offshore outsourcing R&D services. Our results suggest that firms centralizing their R&D activities in their home country are less likely to decide to either outsource or outsource offshore R&D services. We will discuss these findings in the following section.

5. Discussion and conclusion

Our study is aimed at identifying the determinant factors of both outsourcing and offshore outsourcing R&D services. Building on a co-evolutionary framework applied to the field of international business (Hutzschenreuter et al., 2007) we

[5] Graphical analysis of the true interaction effect and *z*-statistic values computed at each observation against the predicted values of the dependent variable is available from the authors upon request.

have argued that these outsourcing decisions will be dependent on the firms' institutional environment, firms' managerial intentionality and path dependency and learning. More specifically, we have argued that firms differ in their propensity to outsource offshore R&D services depending on their international strategy, their accrued technological capabilities, and their home country's intellectual property rights system. An empirical analysis over an international survey on R&D services outsourcing practices has confirmed our hypotheses. As discussed below, the overall pattern of results provides some insight regarding how firms' technological capabilities interact with the institutional environment in their home country and how this interaction explains cross-country differences in both outsourcing and offshore outsourcing.

Technological capabilities play a pivotal role in our analysis. Consistently with the emerging literature that acknowledges the role of firms' capabilities and contractual hazards in governance decisions (Leiblein & Miller, 2003; Mayer & Salomon, 2006), we have expected that a firm's degree of accumulation of technological capabilities will increase its ability to govern transactions. On this basis, we have proposed that the possession of valuable technological capabilities increases the likelihood to both outsource and outsource offshore R&D services. However, we have argued that not all firms are equally able to transform their technological expertise into governance capabilities. Previous research in alliance management has shown that what is known as governance capabilities are the outcome of a process of learning (Westney, 1988) through which firms not only gain experience in these practices but also try to capitalize on it by means of special management techniques (Draulans et al., 2003; Kale et al., 2002; Simonin, 1997). Our results show that this learning is conditioned by the role of the institutional environment, through the intellectual property rights system. The high appropriability hazards resulting from weak protection of intellectual property rights will prevent firms from entering into outsourcing agreements in the domestic market. Our results suggest that this domestic outsourcing experience is critical in explaining the decision to outsource offshore. In fact, when estimating an ordered probit model—with a dependent variable that takes the following values: '0' if the firm does not outsource R&D services; '1' if the firm does outsource R&D services but only to domestic providers; '2' if the does outsource some R&D services offshore; and '3' if the firm does outsource R&D services but only to offshore providers—the obtained results are the same as in the probit model explaining the probability of offshore outsourcing.[6]

These results complement previous research by Barkema et al. (1997), which shows that experience in alliances at the domestic level is critical to manage effectively these operations at the international level. So, even though firms can overcome the restrictions imposed by a weak domestic institutional environment by outsourcing abroad at the beginning, this decision comes at the cost of not gaining enough experience in the management of outsourcing agreements. The domestic environment thus conditions the degree of accumulation of governance capabilities. However, in keeping with a co-evolutionary framework, it is possible to defend that the decision of firms to vertically integrate due to a weak appropriability regime would also reduce the possibilities of future outsourcing agreements at the domestic level. Vertical integration by the most prospective firms would limit the possibilities of development of a local industry of R&D service providers. As our data is cross-sectional, we cannot test this additional hypothesis, although previous research by Jacobides (2005) has shown how the vertical disintegration within a value chain requires inter-firm co-specialization. Thus, even though our study is based on cross-sectional survey data, our results reinforce a co-evolutionary view of international expansion as we find evidence on how firms co-evolve and change their organizational practices depending on the evolution of their own experience and environmental factors.

The third cornerstone of our framework is the firm's international strategy. A firm's strategy is another source of heterogeneity in international business decisions (Hutzschenreuter et al., 2007). We have come to expect that firms with a local responsiveness attitude will have a higher likelihood to outsource offshore R&D services than the rest. Our empirical results and—the ones obtained in the aforementioned additional ordered probit model—have confirmed this hypothesis. In this regard, we find that those firms having a local responsiveness attitude, i.e. those firms adopting a multi-domestic or a transnational corporate strategy (Bartlett & Ghoshal, 1989; Harzing, 2000b) will have a higher propensity to outsource offshore R&D services compared to other firms. This finding suggests that the dispersion of technological knowledge may imply a greater need for firms to engage in finding new sources of knowledge. Consequently, the establishment of R&D outsourcing agreements with offshore providers in the local markets may serve as effective mechanism to identify the potential for new products and services or faster and better access to new technologies. Our results are compatible with the work of Lewin et al. (2009), who found that speeding up the entry of new products into new markets was an important driver of offshoring agreements for product development. Interestingly, the strategies of local responsiveness do not imply a higher propensity to outsource, only to outsource offshore, as in this case the firm needs knowledge located abroad. The decision to outsource and especially to outsource offshore is also conditioned by the firm's concentration of R&D efforts. A firm's decision to concentrate all of their R&D efforts in a specific location allows it to achieve economies of scale, making easy to gain critical mass in their R&D processes. In addition, this integration makes difficult to take advantage of firm-specific knowledge located in other places. For this reason, it is not a surprise that these firms have a lower propensity to outsource, especially offshore.

[6] This additional ordered probit model is available from the authors upon request.

Offshore outsourcing is a business practice related to globalization. But as many other related researchers suggest, globalization does not mean a complete homogenization of business practices around the world (Guillén, 2001; Hutzschenreuter et al., 2007). Our study contributes to identifying several sources of heterogeneity that explain cross-country and inter-firm differences in offshore outsourcing. Obviously, our cross- sectional data does not allow for the testing of every possible co-evolutionary process that can influence international business decisions. However, we have conducted several robustness checks and our results did not change. Even though patent data has been widely used in the literature as a measure of firms' technological capabilities (Bachmann, 1998; Praest, 1998; Tallman & Phene, 2007), we also run all of our models—i.e. both probit models presented in this paper together with the ordered probit model explaining the offshore outsourcing decision—using an alternative measure of firms' technological resources. To do so, we forewent the use of PATENTS in favour of introducing a dummy variable named 'R&D STRATEGY' that takes value '1' if the firm indicated in the questionnaire that 'the R&D activities represent the basis of our company's competitive strategy, so research guides the actions of the remaining areas or departments in our company', and equals '0' otherwise.[7] We obtained the same results. Our estimations are available upon request.

To recap, our results show that in a flat world (Friedman, 2005) not all of the firms have to behave in the same way. Specifically, our main contribution is finding how technological capabilities are not automatically transformed into governance capabilities, as only firms having a sound system of intellectual property rights exploit these capabilities in offshore outsourcing. Complementing Barkema et al. (1997) research we show the importance of domestic experience as a stepping stone in learning processes associated to international expansion. In addition, we also complement the results of Lewin et al. (2009) as we show the importance of taking advantage of firm-specific knowledge located in other countries for firms following a strategy of local responsiveness.

Our study is limited in several aspects. First of all, our data is cross-sectional, so we could not analyze all of the interrelated processes that shape international business decisions. Secondly, unfortunately we could not include all of the developed countries in our study, which means important countries such as Canada or Japan are not included in our sample. Third, our dependent variable does not distinguish between types of R&D services being outsourced. Given that not every R&D service within the innovation process has the same strategic importance, it would be interesting to distinguish the R&D outsourcing decision by type of R&D service being outsourced. However, due to the wide variety of services that can be outsourced together with the different destinations where firms can outsource them, this analysis would deserve an entirely new paper. Due to the low response rate, and even though our respondent firms are representative of the whole population consulted by country of origin, industry and firm size, our results should be analyzed with care. Finally, although additional analyses were carried out using an alternative measure of technological capabilities, we analyzed firms' technological capabilities globally by identifying only their cumulative number of patents.

Bearing these limitations in mind, we can conclude that there still exist aspects related to the propensity to outsource R&D that deserve the attention of researchers. First of all, to carry out empirical studies with longitudinal data that could analyze all of the dynamic interactions between the analyzed factors. Secondly, it can also be taken into account the type of R&D service outsourced (core or non-core) and the location of the R&D service provider. A second way to develop the study would be to analyze separately the impact on R&D outsourcing of the different types of technological advantages a firm may have. Finally, future research might analyze not only the propensity to outsource R&D, but also the effectiveness of outsourcing agreements, as well as the relationship between R&D offshoring and the offshoring of production activities.

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Appendix A

See Fig. A1 and Table A1.

[7] In order to develop this variable we asked managers to indicate which of the following statements best applies to their company: (1) the R&D activities represent the basis of our company's competitive strategy, so research guides the actions of the remaining areas or departments in our company; (2) the R&D department must support our company's competitive strategy, so it must coordinate and align its objectives and actions with the other departments; (3) the R&D department must be effective and competitive but it operates very independently from the other departments; or (4) our company considers that the R&D department has no influence on the company's competitiveness and just buy the technologies available in the market.

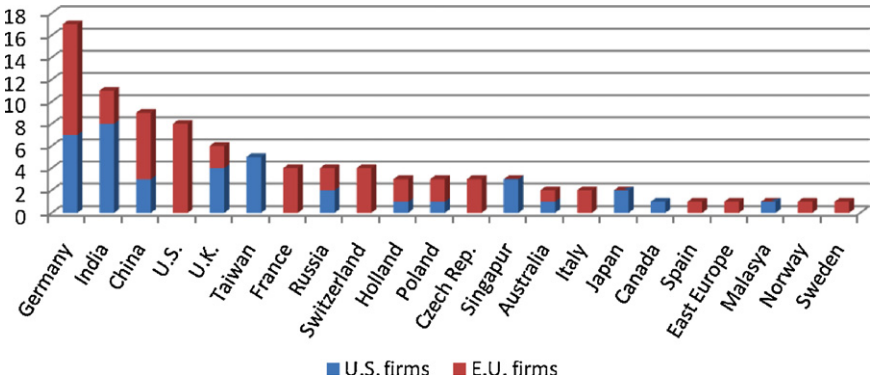

Fig. A1. Location of offshore R&D outsourcing agreements.

Table A1
Distribution of survey responses by country of origin and industry.

	Mailed		Received	
	Number	%	Number	%
Country				
US	2000	50%	81	45%
European Union	2000	50%	101	55%
Austria	56	1.40%	2	1.10%
Belgium	25	0.63%	2	1.10%
Czech Republic	20	0.50%	1	0.55%
Denmark	23	0.58%	0	0%
Finland	32	0.80%	0	0%
France	221	5.53%	9	4.95%
Germany	617	15.43%	24	13.19%
Greece	2	0.05%	2	1.10%
Ireland	17	0.43%	0	0%
Italy	507	12.68%	32	17.58%
Luxembourg	1	0.03%	0	0%
Poland	37	1.93%	3	1.65%
Portugal	13	0.33%	1	0.55%
Spain	93	2.23%	9	4.95%
Sweden	42	1.05%	3	1.65%
The Netherlands	21	0.53%	1	0.55%
UK	249	6.23%	12	6.59%
East Europe	24	0.60%	0	0%
Industry				
SIC 28 (Chemicals)	760	19%	45	24.7%
SIC 35 (Transportation Eq.)	1357	33.93%	58	31.9%
SIC 36 (Electronics)	947	23.68%	40	22%
SIC 37 (Machinery)	487	12.18%	16	8.8%
SIC 38 (Measurement Eq.)	449	11.23%	23	12.6%

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